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A PROCESS CAPABILITY IMPROVEMENT OF MACHINING PARAMETERS OF TEN TON COMPACTOR'S REAR CHASSIS

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ABSTRACT

Process quality is the building block to any organization for ensuring the quality on which the customer thrives and establishing a good relationship between a manufacturer and a customer. The basic three capability indices commonly used in manufacturing industries are Cp, Cpk, Cpm and Cpmk. Process capability indices are intended to provide single number assessment of the ability of a process to meet specification limits on quality characteristics of interest. Thus, it identifies the opportunities for improving quality and productivity. Therefore, understanding the meaning of quality and efforts taken towards its improvement plays a pivotal role in the growth of a company's business. The most effective way towards the improvement of the quality of the product in hand is by eliminating the defects from the process to make it more accurate and precise. Improvement of a process is a long term task which includes problem definition, the source of a problem, root causes which include both primary and secondary and the steps taken towards the optimization. The identification of the problem is possible either by visual inspection or through statistical process control. Process capability analysis is one of the major tools used to determine the process performance as capable or incapable within a specified tolerance which is used for improving the process.

KEYWORDS: Process Capability, Process Capability Analysis, Process Quality, Rear Chassis & Ten Ton Compactor

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Original Article

1. INTRODUCTION

A ten ton compactor is build up on the basis of a rear chassis and a front chassis which are termed as the major component in a ten ton compactor. A compactor is a road roller type engineering vehicle used to compact soil, gravel, concrete or asphalt in the construction of roads and foundation. The first compactors were horse-drawn and were probably just borrowed from implements. Compactors use the weight of the vehicle to compress the surface being rolled (static) or use mechanical advantage (vibrating). It can be of a single drum or of two drums, weighing 5-54 tons. Drums are available in width ranging from 24 to 84 inches. Now over here we are basically dealing with a ten ton compactor in which improvement of machining of a rear chassis of a compactor is our main aim. This change in quality may be due to a number of factors most important variation being in a certain process [1].

2. UNDERSTANDING THE USES OF JIGS AND FIXTURES

- Reduction in cost of production by eliminating the out work and setting up of tools.
- Increase in production.
- High accuracy of parts and ensuring the quality.

- Providing interchange ability.
- To enable stability during machining operations by clamping and fixing the heavy and complex parts to be machined.
- Control the quality check and control expenses.
- Adequacy of less skilled labour and more efficiency.
- Partial automation of work tool job.
- Lowering rate of accidents by increase in safety at work.

2.1 Welding Parameters

Table 1: Welding Parameters

Electrode size	0.8mm	1.2mm	1.6mm
Current (A)	70-170	160-300	250-400
Voltage (v)	16-32	20-30	24-32
Carbon dioxide	15-25%	15-25%	15-25%
Argon flow rate (LPM)	75-85%	75-85%	75-85%

2.2 Machining Centers

SACEM-A & SACEM-B: These are horizontal boring machines similar to DEB but only one machining center. These are used to perform similar operations but the productivity is not as much as DEB.

Traverse X-axis : 5000 mm

Y-axis : 3500 mm

Z-axis : 1600 mm

Rotary table dimensions (SACEM A) : 2*2 m

Table capacity : 25 ton

Spindle diameter : 202 mm

Figure 1: Sacem Machine

2.3 Time Involved before the New Fixture

Firstly the process involved in the manufacturing of rear chassis before the new fixture is:

- Tack welding of the side plates on the fixture.
- Full welding is done inside out of the rear chassis.
- Machining of the parts is done in the sacem machine.
- Painting of the whole body is done.

Now for the development of one rear chassis the time involved in all process to be completed are as shown below:

Total time taken for tack welding = approximate 5 hrs.

Total time taken for full welding = approximate 4 hrs.

Total time taken for machining = approximate 4hrs.

Total time taken for painting = approximate 3 hrs.

Total time taken for loading and unloading of the chassis = around 2 hrs.

So this basically brings out the total time taken to finish the entire job which is:

Total time for the entire process = 1100 mins.

= 18.33 hrs.

Total shift = 2.5 shifts

= (2.5)*(440)

= 1100 mins

As we know that 1 shift = 7.33 hrs, which is further equal to 440 mins.

Figure 2: Rear Chassis of a Ten Ton Compactor

The above figure represents a rear chassis of a ten ton compactor on which we are basically focusing for the above formulated problem and to further gain our objectives in the right manner.

3. METHODOLOGY

3.1 Procedure for Manufacturing Compactor

- Manufacturing of rear chassis
- Manufacturing of front chassis
- Manufacturing of roller drum
- Painting up of the parts & body
- Assembly of the parts.
- Process capability analysis.

3.2 Fixture Designing

Auto caed design of improved fixture

The new fixture has been designed by keeping in mind that it will increase the production rate of the rear chassis and with this it will also increase the production rate of compactor. Even the tolerance value of the process is improved. The different views for this fixture in auto cad design are:

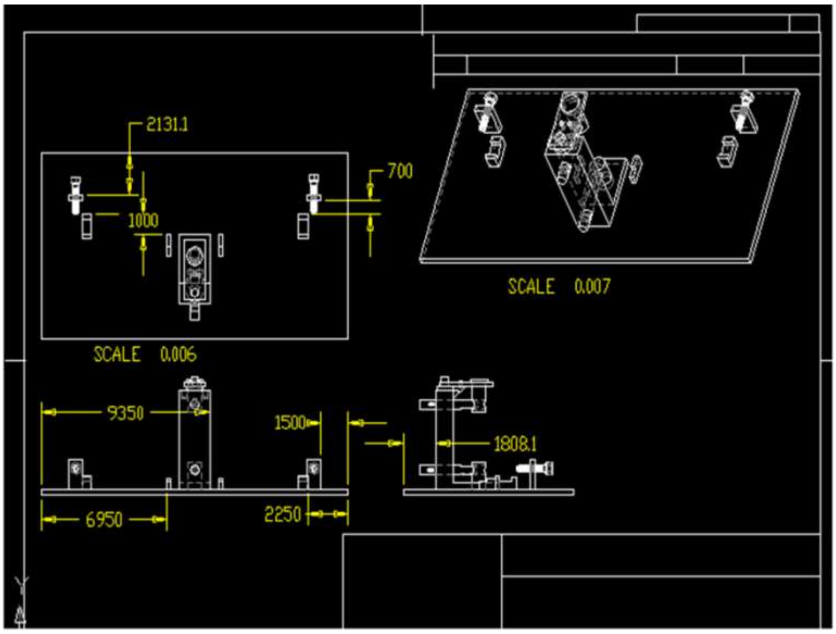

Figure 3: Auto Caed Design of the New Fixture

This is the improved fixture. It has been designed on the AUTO - CAED 2015 software. It helps in checking the perpendicularity of the articulation joint. It helps in checking the co-ordinates of the articulation joint. Accuracy is well maintained for the chassis. The work rate is increased to a faster extent. Performing the job becomes easier for the labour. The fixture is compact in size. Different views of the fixture are shown below:

Figure 4: Top View of Improved Fixture

Figure 5: Front View of Improved Fixture

4. PROCESS CAPABILITY ANALYSIS

Since we are changing the process of manufacturing of rear chassis, so first we need to check whether the process is capable or not. So for this we need to calculate the Cp and Cpk value. Understanding the process and assessing the process performance are essential towards quality improvement initiatives [2].

The formulae used for calculating Cp and Cpk value are:

Cp=(USL-LSL)/6σ

Where over here USL= upper specification limit & LSL= lower specification limit.

Now the other formulae used are:

Sigma= (R bar/d2) (d2 arrives from the table chart)

Now for Cpk the formula is:

Cpk = (USL-MEAN)/((3*STANDARD DEVIATION)) &

Cpk = (MEAN-LSL)/((3*STANDARD DEVIATION))

Now we have to calculate the values of each specific term, for which we will be requiring a check list table which will have the value of all the sub groups that will be created to get the desired values. Different sub groups are created each sub group has three different observations in it.

After the tack welding process is over the different work orders are taken and the values of the perpendicularity and the co-ordinate values of the different work orders are tested to make sure that all the values are lying within the specification limits or not.

4.1 Co-ordinate and Perpendicularity Check Up

Now for tack welding the specific value of the co-ordinates and for the perpendicularity test is as follows:

Specific value of the co-ordinates is= 635cm

Tolerance value= ±0.5cm

For perpendicularity the specific value=±0 degree

The tolerance value for perpendicularity=±0.4 degree

Now the check list table after tack welding is as follows for co-ordinate test is as follow:

Table 2: Co-ordinate Values after Tack Welding

Work order	Actual value
20	635.2
21	635.1
22	634.6
23	635.5
24	634.8
25	635.3
26	635.7
27	634.9
28	635.0
29	635.4
30	634.8

Now the check list table after tack welding for perpendicularity test is as follow:

Table 3: Perpendicularity Check – Up after Full Welding

Work Order	Actual Value (degrees)
20	+0.3
21	+0.2
22	+0.4
23	±0
24	-0.3
25	-0.1
26	+0.15
27	-0.2
28	+0.3
30	+0.2

As we see all the values of the work order are satisfying the specific value of both co-ordinates value as well as perpendicularity of the chassis. So the check list table values are perfectly under the specification limit as checked in the newly designed fixture and can be taken for full welding and after that even the values are to be checked again for proper co-ordinate value and perpendicularity of the chassis.

Now the check list table after the full welding of the chassis for the co- ordinate test is as follow:

Table 4: Co-ordinate Check Up after Full Welding

Work Order	Actual Value
20	635
21	634.9
22	634.8
23	635.1
24	634.8
25	634.9
26	634.8
27	634.9
28	634.8
29	635.1
30	635.2
31	634.8

So we come to see that the co-ordinate test has been successful and the values can be taken for the calculation purpose of Cp and Cpk values. For the perpendicularity test the check list table is as follows:

Table 5: Perpendicularity Check Up after Full Welding

Work Order	Actual Value(Degrees)
20	+0.1
21	+0.1
22	-0.1
23	0
24	-0.1
25	+0
26	-0.056
27	-0.02
28	+0.14
29	+0.1
30	+0.1520

Now we conclude to the checking up of the process capability of the change procedure to rectify that the process is capable and can we followed for the manufacturing up of the rear chassis.

4.2 Calculation of Cp and Cpk value

Observations of the full welding co-ordinate values:

(635, 634.9, 634.8, 635.1, 634.8, 634.9, 634.8, 634.9, 634.8, 635.1, 635.2, 634.8)

Mean value= 635

Number of observations= 12

Upper specification limit value= 635.2

Lower specification value= 634.8

Number of sub groups= 4

Number of items in sub group= 3

Sub Group 1

Observations = (635, 634.9, 634.8)

Now range value (R1) for the subgroup 1= (USL – LSL)

= (635 – 634.8)

= 0.2

Sub Group 2

Observations = (635.1, 634.8, 634.9)

Range value (R2) = (USL – LSL)

= (635.1 – 634.8)

= 0.2

Sub Group 3

Observations = (634.8, 634.9, 634.8)

Range value (R3) = (USL – LSL)

= (634.9 – 634.8)

= 0.1

Sub Group 4

Observations = (635.1, 634.2, 634.8)

Range value (R4) = (USL – LSL)

= (635.1 – 634.8)

= 0.3

So, R bar = (0.2+0.2+0.1+0.3) / 4

= 0.8/4

= 0.2.

σ (sigma) = (R bar/d2), here d2 value is taken from the table

= (0.2/1.693)

= 0.1181

Now the value of Cp = (USL-LSL)/6σ

= (0.4/6*0.1181)

= 0.5644

The maximum value for Cpk = (USL-Mean) / (3*Standard deviation)

= (635.2 – 634.925)/ (3*0.1181)

= 0.7761.

The minimum value of Cpk = (Mean-LSL)/ (3*Standard deviation)

= (634.925 – 634.8)/ (3*0.1181)

= 0.3528

So we select the minimum value of the Cpk which is 0.3528

As we know that the process must be designed in such a way that the Cp value must be greater than Cpk value and both should be less than 1. So over here the values are satisfying as per the requirement. Hence Cp >Cpk and both the values are less then one. Process capability is the range over which the natural variation of the process occurs as

determined by the system of common causes [3].

The value of Cp = 0.5644

The value of Cpk = 0.3528

4.3 Total Time Required for all the Process to be done after the Improvement of the Fixture

Now the process time required after the improvement of fixture to perform all the work which is tack welding followed by full welding and machining and further lead by painting process for proper completion of the manufacturing of the rear chassis. Reduced time involved in various process for the manufacturing of the chassis are as follow:

Total time for tack welding = approximate 2hrs.

Total time for full welding = approximate 2-3 hrs.

Total time for machining = approximate 2 hrs.

Total time for painting = 3 hrs.

Total time taken for loading and unloading = around 1hr.

Total time required = 11 hrs

Number of shifts = 1.5 shifts

4.4 Reduction in Number of Labours and Labour Cost

Further now there is reduction in the number of labours required and thus labour cost got reduced

Reduction in the labour required is as below:

Labours required for tack welding in the earlier process = 2 men/hr.

Labours required for tack welding in the improved process = 1man/hr.

Cost of a labour per day in the earlier process = Rs 1200

Now, cost of labour per day in the improved process = Rs 550

4.5 Estimated Cost of Compactor

Profit from the compactor with the help of the improved process is derived as:

Total price of the compactor is approximated around 20 lakhs.

Direct material cost (DMO) =87% of the selling price

= Rs 17,40,000.

Over head cost (OH) = 6.5% of the selling price

= Rs 1,30,000.

As we know that selling price = (profit + direct material cost + factory over head)

So profit from the compactor = (selling price) – (direct material cost + factory overhead)

= (20,00,000) – (17,40,000 + 1,30,000)

= Rs 1,30,000

Hence we see that the profit of the compactor is made by the improved process.

5. CONCLUSIONS

Hence we conclude that the improved process is capable and can be practiced for further manufacturing up of the rear chassis of a ten ton compactor which will further lead us to reduction of manufacturing time, cost and increasing the production rate. As the per the high market demand this improved process is practiced now in the companies producing ten ton compactor.

The improvisation done in the fixture yielded out these benefits to the company:

- Production rate of the rear chassis is increased from 25 per month to 40 per month.
- Production rate of the ten ton compactor is increased from 6 per month to 12 per month.
- The process is highly capable as Cp value is greater than Cpk value and it is greater than 1.
- There is a huge reduction from 2.5 shifts to 1.5 shifts in the time required to build up a chassis.
- Profit has been increased from the earlier process.
- Promised service levels to customers can be achieved.
- If profits are increased, more products can be launched into the market so that customers can purchase the item and customer can get more benefits and discounts.
- Overall safety inventory costs are reduced leading to the profit of the organization.

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